

**WITH SCIENCE**



**WE DEFEND**

**TECHNICAL REPORT  
NATICK/TR-99/022**

**AD** \_\_\_\_\_

# **REQUIREMENTS ANALYSIS FOR THE PROTECTIVE GLOVES SYSTEM**

by  
**Roger A. Schleper**

April 1999

**19990719 118**

Final Report  
June 1998 - September 1998

Approved for Public Release; Distribution Unlimited

**U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND  
SOLDIER SYSTEMS CENTER  
NATICK, MASSACHUSETTS 01760-5015**

**DTIC QUALITY INSPECTED 4**

## DISCLAIMERS

The findings contained in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

## DESTRUCTION NOTICE

### For Classified Documents:

Follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

### For Unclassified/Limited Distribution Documents:

Destroy by any method that prevents disclosure of contents or reconstruction of the document.

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE  
April 1999

3. REPORT TYPE AND DATES COVERED  
Final June 1998 - September 1998

4. TITLE AND SUBTITLE  
Requirements Analysis for the Protective Gloves System

5. FUNDING NUMBERS  
8CP 12A

6. AUTHOR(S)  
Roger A. Schleper

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)  
U.S. Army Soldier and Biological Chemical Command  
Soldier Systems Center  
ATTN: SSCNC-YA  
Kansas Street  
Natick, MA 01760-5015

8. PERFORMING ORGANIZATION  
REPORT NUMBER  
NATICK/TR-99/022

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING  
AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release, distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

This report documents a user requirements analysis for the Protective Gloves System (PGS). The analysis resulted in recommended modifications to the PGS draft Operational Requirements Document (ORD). The PGS is an Army Soldier Enhancement Program (SEP). The motivation for this SEP originated with a suggestion from a military engineer, which described some deficiencies of the current Barbed Wire Glove. Some of these shortfalls were too much bulk, lack of dexterity, lack of comfort, too cumbersome, etc. Also, feedback from Bosnia and/or Macedonia indicated that huge numbers of Intermediate Cold/Wet Gloves were turned in due to damage from handling Barbed and Concertina Wire. Evidently, users chose to wear the more comfortable Cold/Wet gloves, despite the fact that the directions for these gloves included the phrase "not for use in handling Barbed Wire." The costs generated from this misuse were exorbitant. The proponent for this SEP is the MP School at Ft. McClellan, AL, which developed the draft ORD. This ORD addresses the original concerns of military engineers, plus some of the unique requirements of MPs. Expert Choice (EC), a decision support software tool, was used to help evaluate the user requirements. EC is based on the Analytical Hierarchy Process (AHP), which is a method for prioritizing system characteristics, based on pairwise comparisons.

14. SUBJECT TERMS

PROTECTIVE GLOVES, HUMAN FACTORS, GLOVES, COMFORT, PROTECTION, VERSATILITY, PAIRWISE COMPARISONS, EVALUATION, DURABILITY, BARBED WIRE, REQUIREMENTS, ANALYSIS, TACTILITY, DEXTERITY

15. NUMBER OF PAGES  
42

16. PRICE CODE

17. SECURITY CLASSIFICATION  
OF REPORT  
Unclassified

18. SECURITY CLASSIFICATION  
OF THIS PAGE  
Unclassified

19. SECURITY CLASSIFICATION  
OF ABSTRACT  
Unclassified

20. LIMITATION OF ABSTRACT  
SAR

# TABLE OF CONTENTS

	<u>Page</u>
<b>LIST OF FIGURES</b>	v
<b>LIST OF TABLES</b>	vii
<b>PREFACE</b>	ix
<b>SUMMARY</b>	1
<b>1. BACKGROUND</b>	2
1.1 System	2
1.2 Requirements Analysis	2
<b>2. APPROACH</b>	3
2.1 AHP Outline and Pairwise Comparisons	3
2.2 User Survey	5
2.3 Expert Choice (EC) Priorities	6
2.4 User Comments	7
2.5 ORD Analysis	7
<b>3. DETAILED RESULTS</b>	8
<b>4. RECOMMENDATIONS</b>	20
<b>5. EVALUATION OF ALTERNATIVES</b>	22
<b>REFERENCES</b>	23
<b>APPENDIX – User Comments</b>	25

## LIST OF FIGURES

<b><u>Figure</u></b>	<b><u>Page</u></b>
1. Primary Factor Priorities	9
2. Protection Priorities	10
3. Human Factor Priorities	11
4. Movement and Touch Priorities	12
5. Wound Protection Priorities	13
6. Toxin Protection Priorities	14
7. Movement Priorities	15
8. Hand and Forearm Priorities	16



## LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. AHP Tree for PGS	4
2. Pairwise Comparisons	5
3. EC Weights or Priorities	6
4. MP User Priorities	17
5. Engineer User Priorities	18
6. Infantry User Priorities	19





## **PREFACE**

The purpose of this report is to analyze user requirements for the Protective Gloves System (PGS). The PGS is an Army Soldier Enhancement Program (SEP). The recommendations in this report were made with respect to the PGS draft Operational Requirements Document (ORD).

The Modeling & Analysis Team, at SBCCOM, was tasked by PM-Soldier to perform this requirements analysis. The proponent for this SEP is the MP School at Ft. McClellan, AL, and they developed the draft ORD.

# **REQUIREMENTS ANALYSIS FOR THE PROTECTIVE GLOVES SYSTEM (PGS)**

## **SUMMARY**

This analysis resulted in suggested modifications to the PGS draft Operational Requirements Document (ORD) <sup>1</sup>. The PGS is an Army Soldier Enhancement Program (SEP). The recommended modifications are based primarily on feedback from user surveys and the resulting derived user priorities. These recommendations are described in Section 4.

The user priorities were determined using Expert Choice (EC) decision support software. EC is based on the Analytical Hierarchy Process (AHP), which is a method for prioritizing system characteristics, based on pairwise comparisons. The calculation of user priorities involved the following steps:

- Development of AHP Outline
- Administration of User Surveys
- Expert Choice Execution

The entire analysis approach, including these steps, is explained in Section 2.

The PGS survey asked 39 questions, each question being framed as a pairwise comparison. The surveys were administered to groups of Military Police, Military Engineers, and Infantry. The survey results were then input to the EC model and the PGS priorities were derived for each user group. These priorities are detailed in Section 3. One interesting result was the closeness of first level priority values across all the user groups (Figure 1). The first level criteria are Human Factors, Protection, Durability and Maintenance, and Tactility and Movement Ease.

For this analysis, AHP was used to prioritize system criteria. It can be taken further and used in the analysis of alternatives. Hence, the user priorities contained in this report could be used to analyze PGS alternatives, once these alternatives have been identified. Section 5 outlines the steps that would need to be executed, in order to accomplish this.

## **1. BACKGROUND**

### **1.1 System**

The Protective Gloves System (PGS) is an Army Soldier Enhancement Program (SEP). The PGS is intended to replace the existing Barbed Wire Gloves and also function as Riot Control/Pat-Down Gloves.

The need for the PGS SEP originated from a military engineer's suggestion, which described deficiencies of the current Barbed Wire Glove. Some of these shortfalls were too much bulk, lack of dexterity, lack of comfort, etc. Also, feedback from Bosnia and/or Macedonia indicated that huge numbers of Intermediate Cold/Wet Gloves were turned in due to damage from handling Barbed and Concertina Wire. Evidently, users chose to wear the more comfortable Cold/Wet gloves, despite the fact that the directions for these gloves included the phrase "not for use in handling Barbed Wire". The costs generated from this misuse were exorbitant. Present material technologies can provide a more comfortable glove for hand protection. The proponent for this SEP is the MP School at Ft. McClellan, AL, and they developed the draft Operational Requirements Document (ORD). This ORD addresses the original concerns of the military engineers, plus some of the unique requirements of MPs.

### **1.2 Requirements Analysis**

The Science & Technology Directorate (S&TD), at SSCOM, was tasked by PM-Soldier to analyze user requirements for the Protective Gloves System, using Expert Choice (EC) decision support software. EC is based on the Analytical Hierarchy Process (AHP), which is a method for prioritizing system characteristics, based on pairwise comparisons<sup>2,3</sup>.

## **2. APPROACH**

The results of this requirements analysis are recommendations made with respect to the capabilities stated in the ORD. The analysis involved the following steps:

### **2.1 AHP Outline and Pairwise Comparisons**

The ORD was reviewed and an initial AHP outline was developed for the PGS. This outline consisted of a tree diagram, with various glove criteria on different nodes. The outline was distributed to subject matter experts for review and comment. These experts consisted principally of the PGS SSCOM project engineer and user representatives. Once their feedback was obtained, the final AHP outline was developed. It is documented in Table 1. The first level or primary criteria are Human Factors, Protection, Durability and Maintenance, and Tactility and Movement Ease. The second level criteria under Human Factors are Comfort, Load, and Versatility, and so on.

**Table 1 - AHP Tree for PGS**

**HUMAN FACTORS**

Comfort

Weather conditions (cold, hot, wind, and rain).

Inner material against skin

Fit

Load

Versatility

Removable layers

Removable components

**PROTECTION**

Wounds

Cuts (such as knife slashes and razor edges)

Hand Palms

Hand Tops

Forearms (wrist to elbow)

Punctures

Hand Palms

Hand Tops

Forearms (wrist to elbow)

Abrasions

Hand Palms

Hand Tops

Forearms (wrist to elbow)

Flame/fire

Toxic liquids

Blood pathogens

Hands

Forearms

Petroleum, Oils, and Lubricants

Hands

Forearms

Blunt force trauma

Hands

Forearms

**TACTILITY and MOVEMENT EASE**

Touch sensitivity

Movement Ease (or dexterity)

Fingers Movement (or dexterity)

Index finger

Other fingers

Snag/catch wire

**DURABILITY and REQUIRED USER MAINTENANCE**

Durability (or service life)

Required User Maintenance

The AHP requires a same level pairwise comparison for each pair of related criteria. The AHP outline for the PGS, in Table 1, requires a total of 39 comparisons. Table 2 lists the 6 first level comparisons, the 3 second level comparisons under Human Factors, and the 4 third level comparisons under Human Factors.

**Table 2 – Pairwise Comparisons**

----- 1<sup>st</sup> Level Comparisons

Human Factors vs. Protection  
Human Factors vs. Tactility/Movement Ease  
Human Factors vs. Durability/Required Maintenance  
Protection vs. Tactility/Movement Ease  
Protection vs. Durability/Required Maintenance  
Tactility/Movement Ease vs. Durability/Required Maintenance

----- 2<sup>nd</sup> Level Comparisons under Human Factors

Comfort vs. Load  
Comfort vs. Versatility  
Load vs. Versatility

----- 3<sup>rd</sup> Level Comparisons under Human Factors

Weather conditions vs. Inner material  
Weather conditions vs. Fit  
Inner material vs. Fit  
Removable layers vs. Removable components

Each comparison above results in a magnitude of preference for one criterion or the other. The range of magnitudes, or ratios, are from 1:1 to 9:1. In the user survey described in Section 2.2, the following choices were available:

- 1:1 No preference for either criteria
- 3:1 Moderate preference for one criteria
- 5:1 Strong preference for one criteria
- 7:1 Very strong preference for one criteria
- 9:1 Extreme preference for one criteria

For example, if Comfort were strongly preferred to Load in Table 2, it would be 5 times as important.

## **2.2 User Survey**

A user survey was developed for the purpose of making the pairwise comparisons derived from the AHP tree in Table 1. This survey asked 39 questions, each question being framed as a pairwise comparison. The surveys were administered to 40+ Military Police (MP) users, 40+ Military Engineers, and 80+ Infantry. Within each respective user group, a representative response was needed for each survey question. To accomplish this, the mode of the responses was used.

## 2.3 EC Priorities

The priority of each glove characteristic was determined by executing the EC software. The complete list of PGS priorities or weights, for each user group, is in Section 3. The EC software determined the PGS weights by combining the magnitudes from the 39 pairwise comparisons. Table 3 is an illustration of EC weights, using the AHP outline for the PGS.

**Table 3 – EC Weights or Priorities**

HUMAN FACTORS	.15		
Comfort	.05		
Weather conditions		.025	
Inner material against skin		.01	
Fit		.015	
Load	.025		
Versatility	.075		
Removable layers		.040	
Removable components		.035	
PROTECTION	.55		
Wounds	.20		
Cuts		.10	
Hand Palms			.05
Hand Tops			.025
Forearms			.025
Punctures		.075	
Hand Palms			.05
Hand Tops			.015
Forearms			.01
Abrasions		.025	
Hand Palms			.01
Hand Tops			.01
Forearms			.005
Flame/fire	.05		
Toxic liquids	.20		
Blood pathogens		.15	
Hands			.1
Forearms			.05
Petroleum, Oils, and Lubricants	.05		
Hands			.04
Forearms			.01
Blunt force trauma	.1		
Hands		.07	
Forearms		.03	
TACTILITY/MOVE	.20		
Touch sensitivity	.05		
Movement Ease	.15		
Fingers Movement		.1	
Index finger			.05
Other fingers			.05
Snag/catch wire		.05	
DUR./MAINT.	.10		
Durability	.075		
Maintenance	.025		

The sum of the primary factor weights always equals one, as in this case  $.15 + .55 + .20 + .10 = 1$ . The primary factors are Human Factors, Protection, Durability and Maintenance, and Tactility and Movement Ease. The sum of a group of related subfactors equals the weight of the next level or "parent" factor. For example, the sum from Wounds, Flame/Fire, Toxic liquids, and Blunt force equal the Protection weight, or  $.20 + .05 + .20 + .10 = .55$ . The weights give a relative preference for any two criteria. For example, Tactility and Movement Ease is twice as important as Durability and Maintenance, since  $.20 / .10 = 2$ , and Protection from Cuts is 4 times as important as Load, since  $.10 / .025 = 4$ .

## **2.4 User Comments**

For the purposes of obtaining additional feedback, the surveys allowed for user comments. These comments are recorded in the Appendix. In some cases, they provided additional rationale for the recommendations in Section 4.

## **2.5 ORD Analysis**

Data from this requirement analysis were compared with the capabilities section in the ORD. This data consisted of bar charts of PGS priorities from Section 3, and user comments from the Appendix. Based on this comparison, recommendations were made (Section 4).

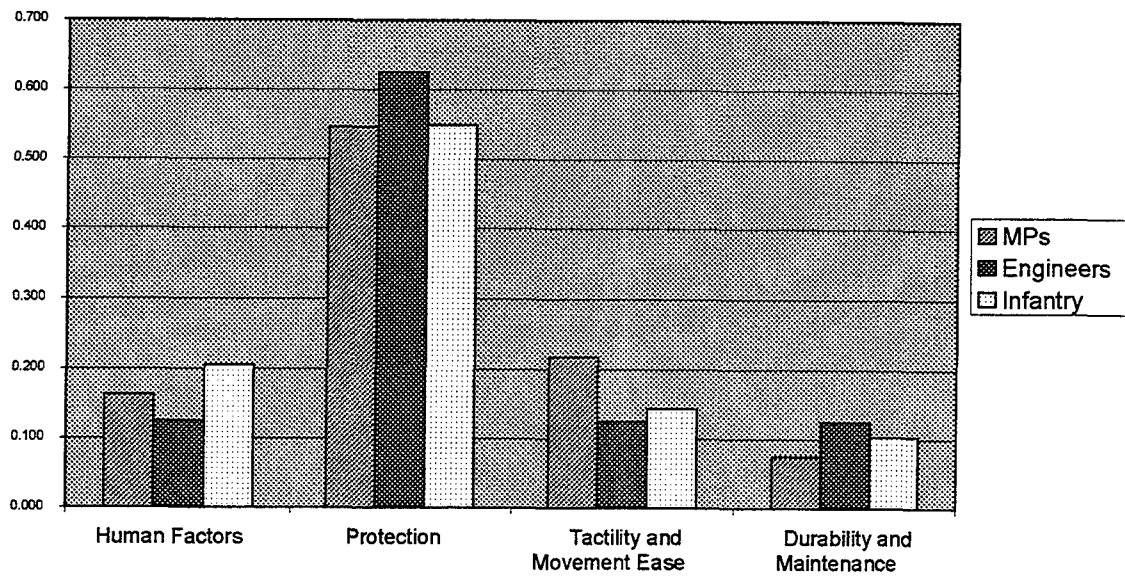


### 3. DETAILED RESULTS

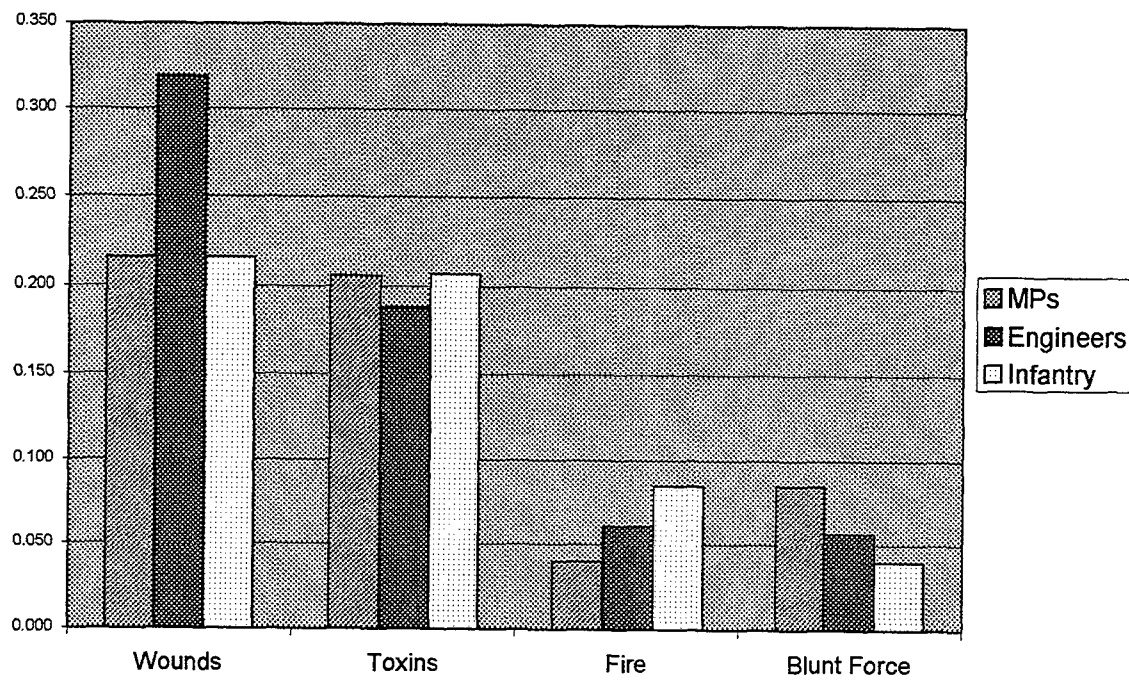
The PGS survey asked 39 questions, each question being framed as a pairwise comparison. The surveys were administered to 40+ Advanced Noncommissioned Officer Course (ANCOC) MPs at Ft. McClellan, 40+ ANCOC Engineers at Ft. Polk, and 80+ ANCOC Infantry at Ft. Benning. The mode for each survey question was chosen as the magnitude of preference, within the respective user group. Approximately 10% of the total surveys administered were filled out incorrectly and had to be discarded. This did not have a significant impact on the results, since the number of sample sizes remained relatively large, even with this 10% loss.

Figures 1-8 are bar charts illustrating how priorities of the three user groups compare for various glove criteria. The priorities produced for each individual user group of all the PGS criteria from the AHP tree are listed in Tables 4-6. One interesting result was the closeness of first level priority values across all the user groups (Figure 1).

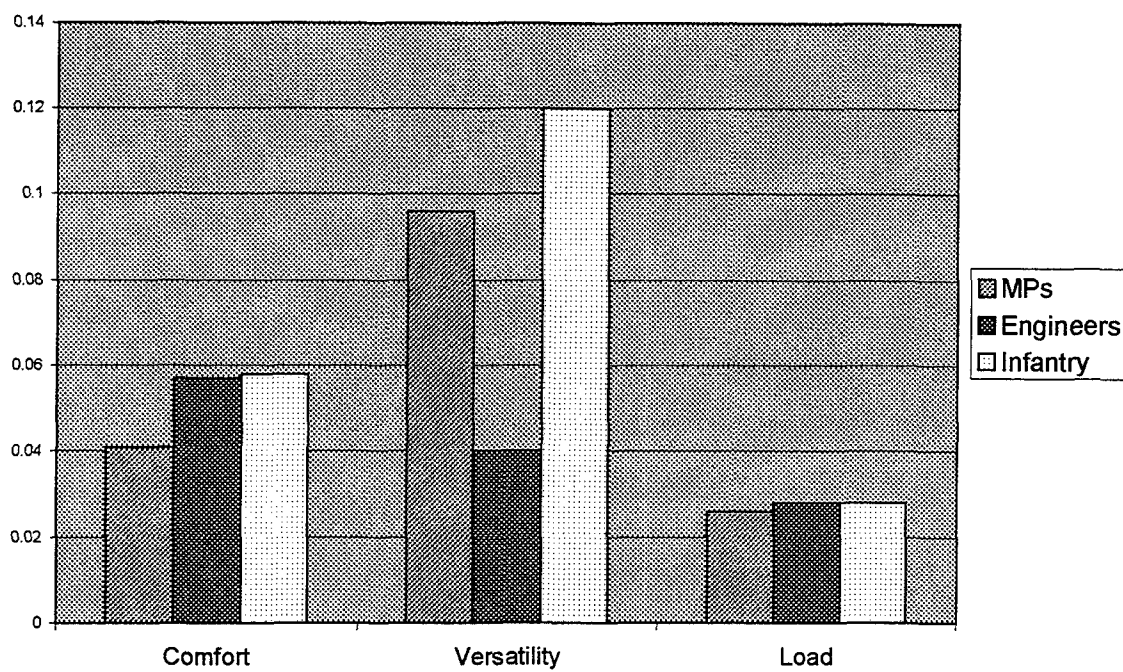
The overall inconsistency indexes for the PGS priorities were .04, .02, and .04, for the MPs, Engineers, and Infantry, respectively. Expert Choice calculates the inconsistency index to measure the level of consistency between priorities. Some amount of inconsistency ( $< .1$ ) is natural. Any value  $> .2$  would probably be cause for a reevaluation of the results. The following example illustrates the concept of inconsistency. Suppose criteria A is judged to be twice as important as criteria B and B is judged equal to criteria C. Then for 0 inconsistency, A would be judged twice as important as C. If the relationship between A and C is anything else, inconsistency would be  $> 0$ .



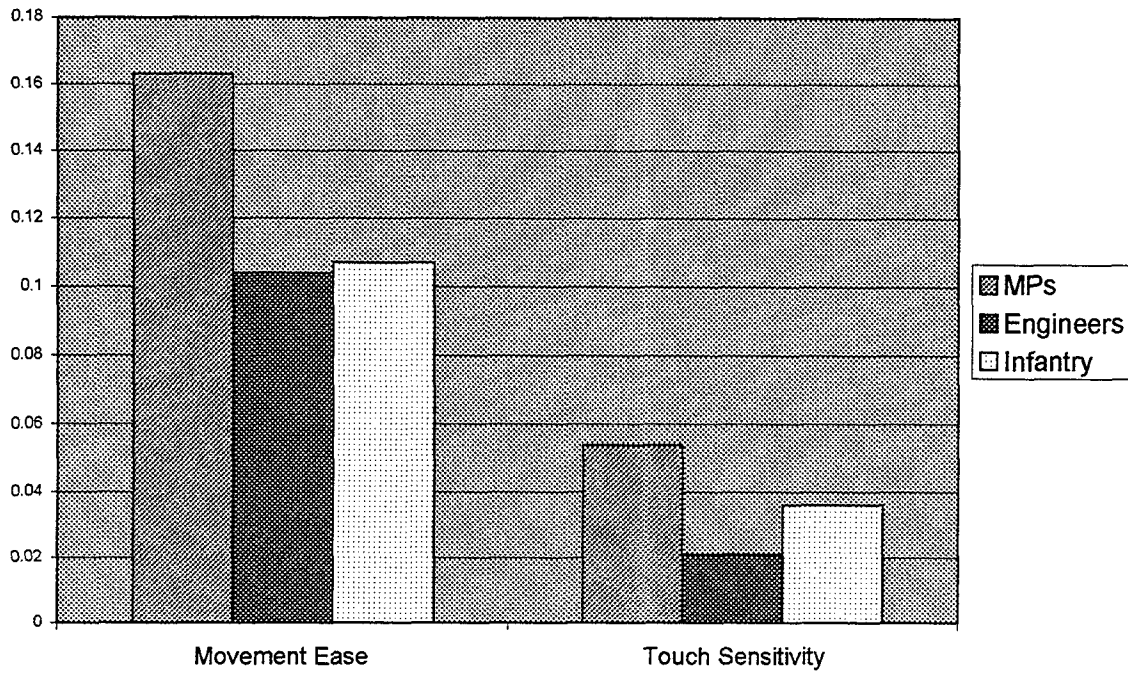
**Figure 1 - Primary Factors Priorities**



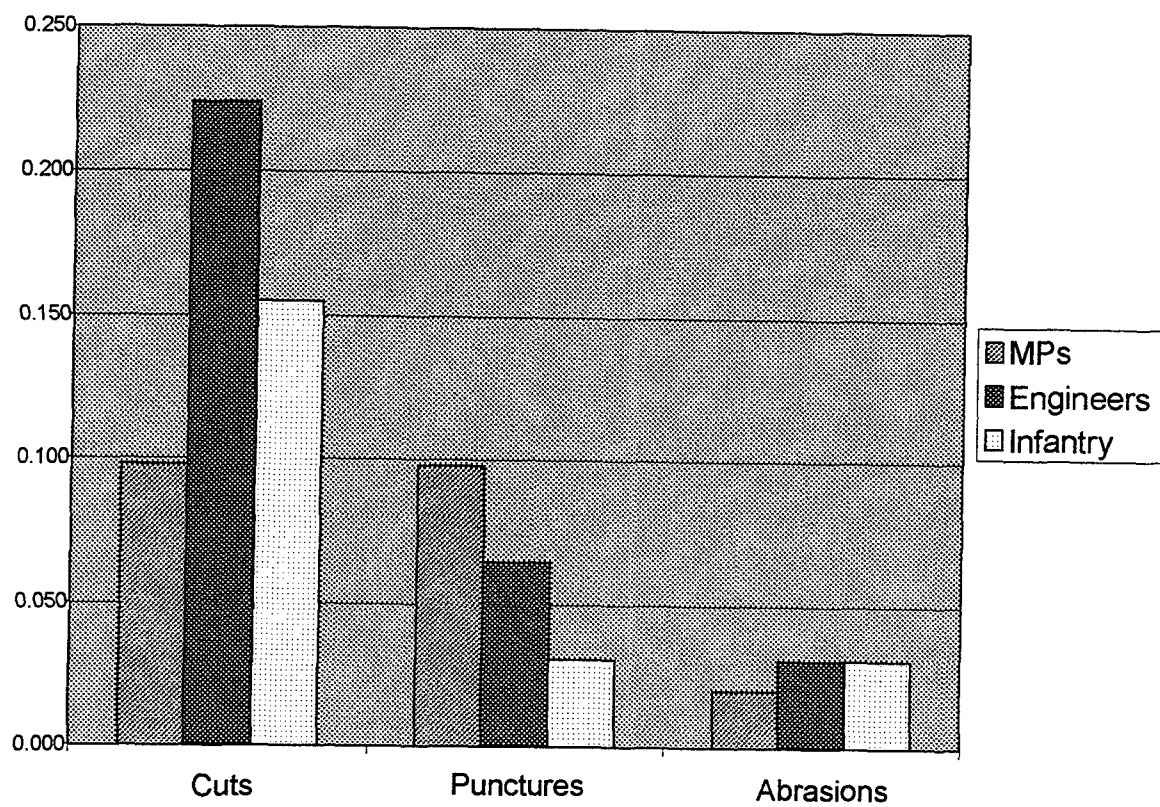
**Figure 2 - Protection Priorities**



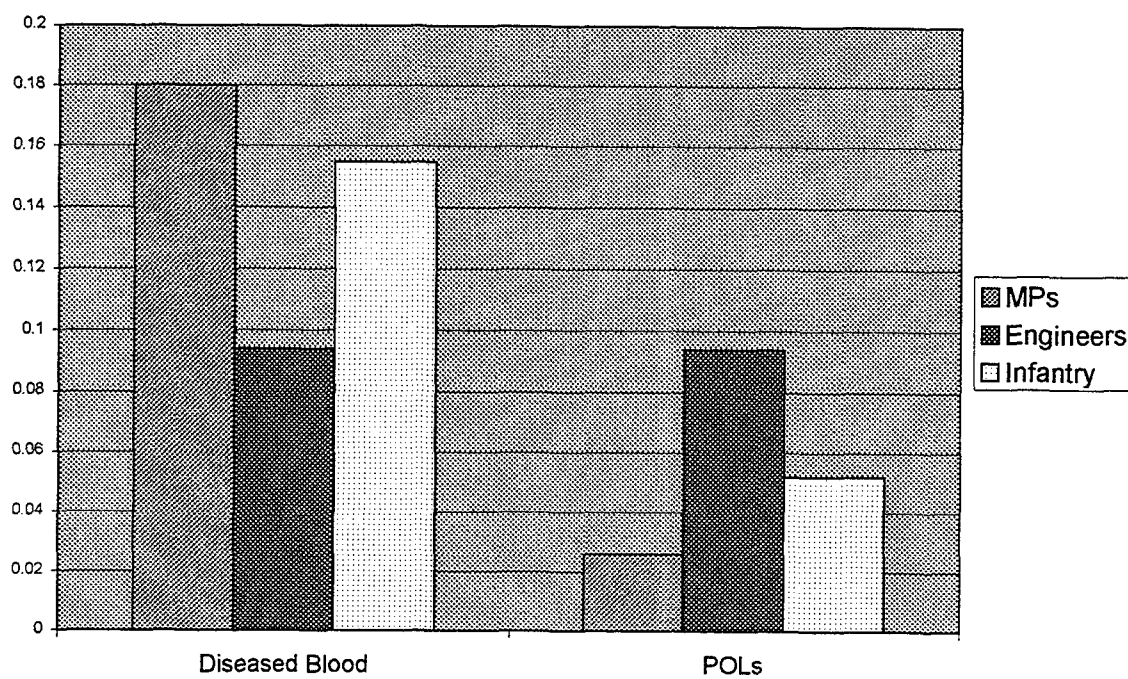
**Figure 3 - Human Factors Priorities**



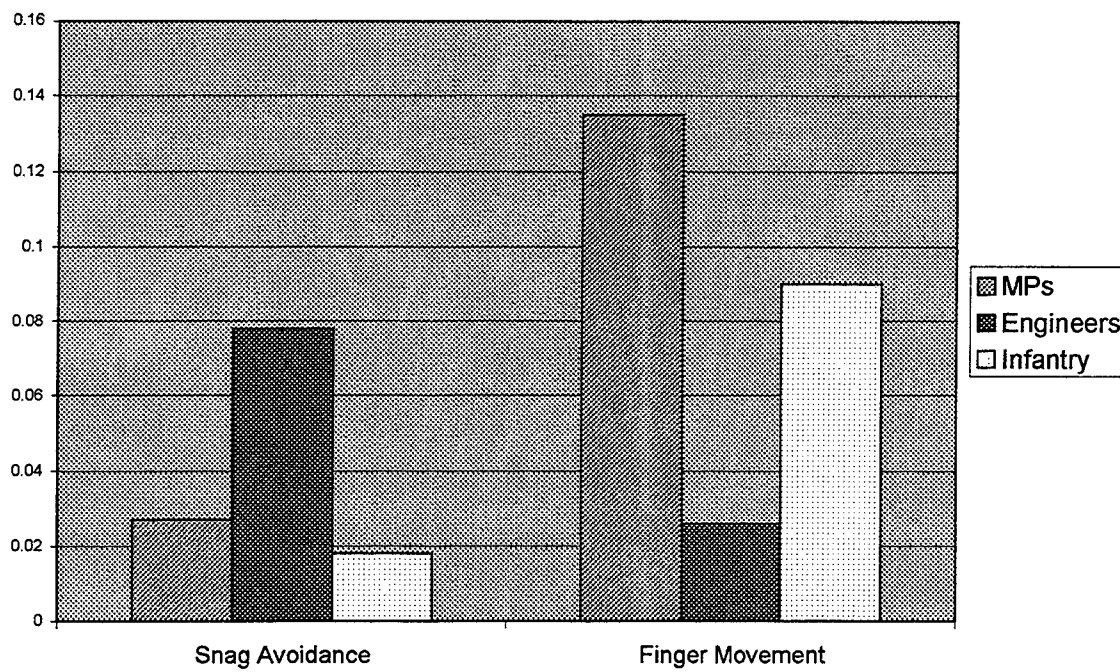
**Figure 4 - Movement and Touch Priorities**



**Figure 5 - Wound Protection Priorities**

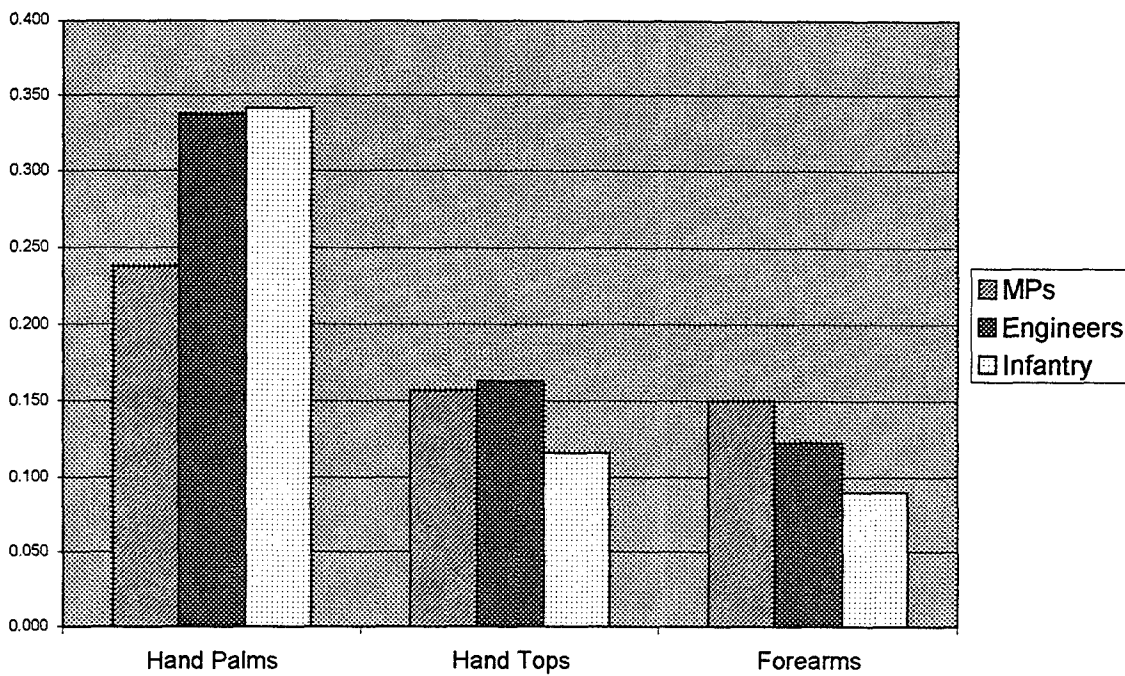


**Figure 6 – Toxin Protection Priorities**



**Figure 7 – Movement Priorities**





**Figure 8 - Hand and Forearm Priorities**

Table 4 - MP User Priorities

OVERALL INCONSISTENCY INDEX = 0.04

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Protect =.546			
	Wounds =.216		
		Cuts =.098	
			Palms =.059
			Tops =.020
			Forearms=.020
		Puncture=.098	
			Palms =.058
			Tops =.024
			Forearms=.015
		Abrasion=.020	
			Palms =.012
			Tops =.004
			Forearms=.004
	Toxins =.206		
		Blood =.180	
			hands =.150
			forearms=.030
		POLs =.026	
			hands =.021
			forearms=.004
	Blunt =.085		
		forearms=.064	
		hands =.021	
Tact =.217	Fire =.040		
	Move =.163		
		Fingers =.135	
			Index =.068
			Other =.068
		Snag =.027	
Human =.163	Touch =.054		
	Vers =.096		
		Layers =.048	
		Comp =.048	
	Comfort =.041		
		Weather =.024	
		Fit =.011	
		Material=.005	
	Load =.026		
DurandRel =.075			
	Durable =.062		
	Reliable=.012		

Table 5 - Engineer User Priorities

OVERALL INCONSISTENCY INDEX = 0.02

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Protect =.625			
	Wounds =.319		
		Cuts =.224	
			Palms =.160
			Tops =.032
			Forearms=.032
		Puncture=.065	
			Palms =.046
			Tops =.009
			Forearms=.009
		Abrasion=.031	
			Palms =.018
			Tops =.008
			Forearms=.005
	Toxins =.188		
		Blood =.094	
			hands =.075
			forearms=.019
		POls =.094	
			hands =.071
			forearms=.024
	Fire =.061		
	Blunt =.057		
		hands =.043	
		forearms=.014	
DurandRel =.125			
	Durable =.104		
	Reliable=.021		
Human =.125			
	Comfort =.057		
		Weather =.034	
		Fit =.016	
		Material=.008	
	Vers =.040		
		Layers =.030	
		Comp =.010	
	Load =.028		
Tact =.125			
	Move =.104		
		Snag =.078	
		Fingers =.026	
			Index =.013
			Other =.013
	Touch =.021		

Table 6 - Infantry User Priorities

OVERALL INCONSISTENCY INDEX = 0.04

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Protect =.549			
	Wounds =.216	Cuts =.155	Palms =.108 Tops =.031 Forearms=.015
		Puncture=.031	Palms =.022 Tops =.006 Forearms=.003
		Abrasion=.031	Palms =.020 Tops =.008 Forearms=.003
	Toxins =.207	Blood =.155	hands =.129 forearms=.026
		POLs =.052	hands =.043 forearms=.009
	Fire =.085		
	Blunt =.040	hands =.027 forearms=.013	
Human =.205	Vers =.120	Layers =.100 Comp =.020	
	Comfort =.058	Weather =.039 Fit =.013 Material=.006	
	Load =.028		
Tact =.143	Move =.107	Fingers =.090	Index =.067 Other =.022
		Snag =.018	
	Touch =.036		
DurandRel =.103	Durable =.086		
	Reliable=.017		

#### 4. RECOMMENDATIONS

These recommendations are with respect to the draft PGS ORD. They are based primarily on the user input to the surveys and the resulting EC priorities. The figures referenced in this section are from Section 3.

i. ORD Section 4. Leave out blunt trauma from first sentence so that it reads "CAPABILITIES REQUIRED. A Protective Glove System is required to provide hand and forearm protection from cuts, abrasions, and toxic fluids." In 4.a.(7) blunt trauma protection can be described as desired.

*Rationale:* Figure 2 illustrates a relatively low priority among all users. This is something that could be traded off, if necessary. In other words, blunt trauma protection is a PGS characteristic that should be able to be reduced or eliminated, if it adversely affects obtaining some higher priority PGS characteristic.

ii. ORD Section 4.a.(2). Change so that it reads "It is desired that the PGS provide the tactility and dexterity necessary to don and remove the current and developmental chemical/biological field mask."

*Rationale:* There may be a work around to this issue. Why can't the gloves be removed, the mask put on, and then the gloves put back on? Also, the main purpose of the PGS is to allow soldiers to handle razor wire, barbed-tape, hypodermic needles, razor blades, etc. effectively and without the danger of injury. This they may do on a daily or regular basis. To require that the PGS have the dexterity to remove a chemical mask, which could be difficult to take off, might force a undesirable design tradeoff. In this case, the loser may be the accomplishment of the main missions. In addition, the EC survey indicates that touch sensitivity (tactility) is a low priority within all three user groups (Figure 4). Finally, the burden should be on the chemical masks. In other words, the chemical mask ORDs should require that they be "easy" to put on and take off.

iii. ORD Section 4.a.(7). Change so that it reads "It is desired that the PGS provide protection from blunt force trauma to the hand and forearm."

*Rationale:* Figure 2 illustrates a relatively low priority among all users. This is something that could be traded off, if necessary.

iv. ORD Section 4.a.(8). Change so that it reads "It is desired that the PGS provide a high degree of tactility as to feel small items hidden in pockets."

*Rationale:* Figure 4 illustrates a low priority for touch sensitivity, among all users. This is something that could be traded off, if necessary.

v. ORD Section 4.a.(14). Add second sentence as follows: "It is desired that the PGS allow user comfort to be maintained as well, in all these climatic conditions."

*Rationale:* There were numerous user comments regarding comfort in various climatic conditions. Also, past experience in Bosnia indicates that users will look for alternatives when not comfortable. In Bosnia, soldiers chose to wear the more comfortable Cold/Wet gloves, despite the fact that the directions for these gloves included the phrase "not for use in handling Barbed Wire." The costs generated from this misuse were exorbitant.

vi. ORD Section 4.a.(15). Add second sentence as follows: "It is desired that the PGS be waterproof and breathable."

*Rationale:* There were numerous user comments regarding comfort in various climatic conditions. Also, past experience in Bosnia indicates that users will look for alternatives when not comfortable. In Bosnia, soldiers chose to wear the more comfortable Cold/Wet gloves, despite the fact that the directions for these gloves included the phrase "not for use in handling Barbed Wire." The costs generated from this misuse were exorbitant.

vii. ORD Section 4.a.(18). Change so that it reads as follows: "The PGS should be designed and shaped to the normal curve and bend of the hand, to provide better comfort to the user. It should be accepted by at least 80% of the users, with respect to comfort. It is desired that the PGS be accepted by 95% of the users, with respect to comfort."

*Rationale:* Same as v. Also, the glove is required to fit 95% of all users in ORD Section 4.a.(13), so the desired comfort acceptance should be 95%. To allow for some tradeoff ability, a lower number of 75-80% should be acceptable. But 50% seems too low.

viii. Add capability to ORD Section 4.a., as follows: "It is desired that the PGS be snag resistant when the soldier is working with concertina razor-edged wire."

*Rationale:* Figure 7 illustrates the concern Military Engineers have with snagging. Also, there were comments with regard to the gloves being pulled off.

## 5. EVALUATION OF ALTERNATIVES

For this analysis, AHP was used to prioritize system criteria. It can be taken further and used in the analysis of alternatives. Hence, the user priorities contained in this report could be used to analyze PGS alternatives, once they have been identified. Analyzing future PGS alternatives, using the AHP priorities in this report, would involve the following steps:

- i. Select the criteria to use in the evaluation. This might be just the first level criterion, it could be all levels of criteria, or it could be something in between.
- ii. Determine a scoring mechanism for each selected criteria. For example, comfort might be graded for each glove prototype by asking users to give it a mark between 1 and 10.
- iii. Score the selected prototypes. Each alternative PGS would have to be scored for each selected criteria. This scoring could take place in the lab or in the field, whichever is appropriate for the individual criterion.
- iv. Prioritize the user groups. For example, since MPs and Engineers are viewed as the primary users of the PGS, they might be each given 40% priority, with 20% going to the Infantry.
- v. Execute the EC models for each user group, with all the PGS alternatives. Combine the user group results by using the user group weights from iv., for example 40-40-20.
- vi. Prioritize cost against benefits, if a cost-benefit analysis is desired. The benefit weight for each PGS alternative would come from v.

This document reports research undertaken at the U.S. Army Soldier and Biological Chemical Command, Soldier Systems Center, and has been assigned No. NATICK/TR-99/022 in a series of reports approved for publication.

## REFERENCES

1. "Draft Operational Requirements Document for Protective Glove System", Directorate of Combat Developments, Military Police School, Ft. McClellan, AL, undated.
2. Expert Choice, Inc., Decision Support Software User Manual, 1995.
3. Saaty, Thomas. Multicriteria Decision Making: The Analytical Hierarchy Process, McGraw-Hill, 1990.





## **Appendix**

### User Comments

## **MP User Comments**

### **Human Factors**

- 1) "We carry too much – need to maintain light weight as much as possible."
- 2) "For SRT and Pat down gloves, fit is very important."
- 3) "The glove must fit to be comfortable. Without good comfort against the skin you also would not want to wear it."
- 4) "In the military we work under all weather conditions."
- 5) "Removable inner layers affect fit too much."
- 6) "Throughout my career, the military gloves have not been effective for me. I bought a pair of civilian thinsulate gloves that kept my hands warm during cold weather operations."
- 7) "If they don't feel good, soldiers won't or may not wear them. Fit and comfort are equal."
- 8) "Versatility would allow each mission to dictate type of glove."
- 9) "Soldiers will not wear these gloves if they do not afford cold weather protection. If they don't, don't even buy them, it's a waste of money."

## **Protection**

- 1) "Protection against both cuts and punctures is vital. However, I feel drug use may make a needle puncture potentially more dangerous or lethal."
- 2) "Caution can make prevention of forearm cuts a lot easier, or less likely, than hand cuts."
- 3) "Forearm is a lot easier to fracture, and harder to cover up during an affray."
- 4) "Both (protection of forearms and hands from diseased blood), are very important. Diseased blood can be lethal. There should be no compromise here."
- 5) "TAC-Gloves (Civilian) offer some protection against moisture and cuts. They do not have protection against punctures. They also provide no protection in the winter and do not breathe in the summer. More power to your research to develop a glove, which is lightweight, durable, and able to handle anything thrown, handled, or mishandled in the course of our duties."
- 6) "Both (protection from cuts and punctures) are very important. However, chances (of avoiding injury) are better with just a needle."
- 7) "Give the corrections field a good protective glove that is suitable for contact against a hostile/violent inmate and a separate glove, lighter duty which protects against hazards involved with frisk searches and cell shakedowns."
- 8) "How (about protection from) electrical (shock)?"
- 9) "Fingers most likely for punctures."

## **Tactility and Movement Ease**

- 2) "I would love to have a glove that could accomplish both tactility and protection."

## **Durability and Required Maintenance**

- 2) "Things last longer when properly cared for. Durability usually means heavy, thick, and almost unusable."

## **Engineer User Comments**

### **Human Factors**

- 1) "Comfort of inner material is important), "because gloves are used for a long period of time and become sore."
- 2) "The better the fit, the more effective the gloves are. Gloves are hard to use in cold."
- 3) "Removable layers help adapt to weather."
- 4) "The fit of the glove should be important because if it doesn't fit right, there would be extreme discomfort."
- 5) "If a glove is not comfortable in different weather conditions, then the individual would most likely choose not to wear it."
- 6) "Removable components would be more convenient than removable layers, to a soldier."
- 7) "The gloves are too bulky and are hard to work with. The metal staples on the gloves get very hot after being in the sun."
- 8) "Good fit prevents gloves from slipping off during work activity."
- 9) "Want versatility and not a heavy, bulky glove."
- 10) "I have small hands, and all the gloves I've ever used have been too large. The sweat from my hands make those big gloves slippery."
- 11) "A glove that fits would be nice, a warm glove that fits would be even better."
- 12) "The gloves tend to fall or get snatched off too easily."
- 13) "The gloves are too bulky. They should be more like regular work gloves."
- 14) "Gauntlet gloves are effective if maintained, but they are bulky and they feel like you are working with a couple of outdoor canvas tents."
- 15) "I want a glove that is comfortable and fits."
- 16) "When handling concertina, gloves always stay on concertina and come off hand because the current glove is too big."
- 17) "Fit is a little more important than comfort."
- 18) "It is very hard to work if your hands are burning up and sweating or if they are frozen to the bone."
- 19) "Removable layers make it easier to adjust to temperature and climate."
- 20) "It is very hard to work effectively if the gloves are uncomfortable."
- 21) "Being versatile is a good thing, but gloves are easier to work with when they are more comfortable."

- 22) "Gauntlet gloves always hook onto the concertina wire and pull off of the hands. They are made too big."
- 23) "Black gloves get very hot in heat. In rain, they get slimy and fall off your hands even easier."
- 24) "It would be nice to add or take away protection when needed in certain situations (with respect to removable layers)."
- 25) "Concertina and barbed wire are always being caught in the gauntlet gloves and slowing down work."
- 26) "When it's cold outside and you're putting the wire up or taking it down, you don't want the glove to keep falling off."
- 27) "If it is hot out and your hand starts sweating you can take them off (with respect to removable layers)."
- 28) "The glove must fit in order to actually perform with wire."
- 29) "The (glove) weight may be a factor in working with concertina wire."
- 30) "A soldier may need to remove a component or layer to be comfortable in working."

## **Protection**

- 1) "I would worry more about protecting my hands than my forearms."
- 2) "If protected for punctures it would be protected for cuts."
- 3) "Working with razor wire, your forearm is exposed to cuts."
- 4) "If a glove protects your arms, nobody would care how heavy it was."
- 5) "I've been cut on my forearms more than my hands."
- 6) "Oil on hands from working around vehicles can mess up your working ability."
- 7) "I do not think the gloves should go as long as to protect the elbows."
- 8) "There needs to be some protection from punctures in the area between the thumbs and forefinger."
- 9) "The gloves will be used more for concertina and razor wire. Slashes are a major problem."
- 10) "Neither punctures or abrasions are a problem in my field."
- 11) "You handle things with your palms, not the hand tops."
- 12) "Your forearms get cut up, but not as much as your hands."
- 13) "Hand tops almost never get cut."
- 14) "Concertina and barbed wire cut through gauntlet gloves."

15) "Stitching on gloves needs to be made stronger, especially when dealing with wire. (The stitching) on fingertips and in between fingers are always coming apart and barbed wire is always cutting us."

16) "Most cuts seem to come on the palm of your hand."

17) "I don't think you get cut on the forearm as much as the hands."

### **Durability and Required Maintenance**

1) "The glove now is fine as long as they are in good condition. Once the leather wears out they should be replaced. Waterproofing also helps these gloves last."

### **Combined Factors**

1) "Suggestion: If you use a neoprene liner with a kevlar over the liner, inside the old gloves, you will get dexterity and will save money because kevlar is extremely durable and is virtually cut resistant."

## **Infantry User Comments**

### **Human Factors**

- 1) "Must be totally waterproof."
- 2) "Must keep hands warm."
- 3) "(Load is not that important) because gloves will not present that much of an additional burden."
- 4) "As a mechanized infantry soldier, weight is not that much of an issue, compared to a light airborne, air assault or ranger infantry soldier."
- 5) "The glove has to fit properly, so it can be effective to work in."
- 6) "The glove has to keep the soldier comfortable, or they won't wear it."
- 7) "The soldier would rather have a glove that will keep him protected from the elements, than a glove with a nice soft lining."
- 8) "Having removable layers helps in adjusting to weather changes. It also helps with the cleaning."
- 9) "I like a glove that I can use all around. That way I don't have to carry more than one."
- 10) "Comfort would not be as important to me, if a glove is not to be worn for extended periods of time."
- 11) "Comfort in cold and wet weather is most important."
- 12) "Glove should not be made with removable liners if possible. Reason: Increased cost, increased accountability, and increased maintenance that is not needed or desired."
- 13) "Gloves don't weight enough to be a weight or bulk concern."
- 14) "Weight is not an issue. Bulk is the main concern in order to be able to move fingers and handle objects, etc. Waterproof is a must."
- 15) "Protection in different weather conditions is very important for mission accomplishment."
- 16) "If a glove is comfortable, soldiers will be more apt to wear it."
- 17) "By separating the item (removable components) you will make it easier to lose pieces and forget them in the barracks."
- 18) "Keeping a soldiers hands warm and dry increases motivation and performance of that soldier in both the garrison and the field."
- 19) "To have a soft inner lining such as polypropylene is extremely comfortable."
- 20) "A removable liner would allow the soldier to dry his gloves easier."
- 21) "Comfort is always #1 priority."



## **Protection**

- 1) "Concertina wire will do the most damage."
- 2) "Diseased blood not a big concern in military."
- 3) "Likelihood of contact with diseased blood is remote."
- 4) "If a glove can protect against cuts, I'm sure it can protect against scrapes."
- 5) "The Ulnar nerve runs along the wrist and palm, so this is very important."
- 6) "You cannot function with a cut on your palm."
- 7) "Soldiers constantly work with wire."
- 8) "Scrapes never hurt anyone."
- 9) "The palms of soldiers don't really ever get cut or scratched. The tops are always being nicked or scratched."
- 10) "Petroleum such as diesel can cause cold weather injuries."

## **Tactility and Movement Ease**

- 1) "Soldiers hands need to be able to fire."

## **Durability and Required Maintenance**

- 1) "Soldiers tend not to maintain equipment of this type, unless inspections are conducted."
- 2) "Durable, strong gloves will save government funds in the long run."

## **Combined Factors**

- 1) "The ideal infantry glove will allow movement of fingers, be waterproof, warm, provide protection from hot weapon barrels, cuts due to concertina wire, and punctures due to black palm."